Mary J. Rathbun 1907

THE CELTIC PROVINCE:
ITS EXTENT AND ITS MARINE FAUNA.

AN ADDRESS

DELIVERED AT

THE ANNIVERSARY MEETING

OF THE

HERTFORDSHIRE
NATURAL HISTORY SOCIETY,

On the 28th of April, 1908, *at Watford*,

BY

CANON ALFRED MERLE NORMAN,

M.A., D.C.L., LL.D., F.R.S., F.L.S.

PRESIDENT OF THE SOCIETY.

[*From the* 'TRANSACTIONS OF THE HERTFORDSHIRE NATURAL HISTORY SOCIETY,' Vol. XIV, Part 1, September, 1909.]

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THE CELTIC PROVINCE: ITS EXTENT AND ITS MARINE FAUNA.

In the year 1859 there was published the 'Natural History of the European Seas,' by Professor Edward Forbes, edited and continued by Robert Godwin-Austen. This work gave an admirable review of all that was then known respecting the distribution of animal life in the Marine Provinces of which it treated. But since that period the exploration of the North Atlantic has been so greatly extended that certain views formerly enunciated no longer hold good.

It was maintained in 1859 that living forms could not exist in the abyss of the ocean, it being argued that the enormous pressure of the superincumbent mass of water must gradually, and ultimately entirely, lead to the extinction of animal life. Forbes wrote: "As we descend deeper into this region" (i.e. of deep-sea corals) "its inhabitants become more and more modified, and fewer and fewer, indicating our approach towards an abyss where life is either extinguished or exhibits but a few sparks to mark its lingering presence. Its confines are yet undetermined"; but elsewhere he expresses his belief that the zero of animal life will probably be in about 300 fathoms.

Extended soundings, dredgings, and trawlings in all oceans have since proved that a very different state of things prevails. At no depth in the ocean is life extinct, and it is an interesting fact that the life which exists in the abyss is characterized by many peculiar forms which find their allies in geological strata of very distant ages.

The existence of varied animal life at enormous depths was finally proved in the dredgings of the "Porcupine" in 1869, when Professor Wyville Thomson procured living animals belonging to most classes of the Invertebrata, at a depth of 2,435 fathoms, about 200 miles south-west of Ushant in Brittany. Since that time it has been proved that at however great a depth a dredge or trawl has swept the bottom, fishes and all classes of the Invertebrata are found to be represented in the material brought up.

It had been the speculation of writers from a very early period that the greatest depths of the ocean would correspond closely with the height of the highest mountains, and it is remarkable that the speculation has been proved to be true. Mount Everest in the Himalayas is 29,002 feet (about $5\frac{1}{2}$ miles) high, while the greatest known depth of the ocean, which occurs in the Pacific near the Fiji Islands, was found by Captain Aldrich to be 5,155 fathoms (i.e. 30,930 feet, or about 6 miles), and the soundings of Professor Agassiz near the same spot gave 4,762 fathoms (= 28,572 feet).

We now pass to some considerations on the Marine Fauna of our own seas. Fifty years ago it was generally agreed that 100 fathoms was to be taken as the limit of its range. Between the British Islands themselves this depth is rarely exceeded, and can only be found in small areas. Yet it is exceeded in certain places, and a hundred-fathom limit would exclude from our fauna portions of our interinsular seas. Of such areas the largest lies in the Irish Sea between the North of Ireland and England. In this trough, which is about 30 miles long, there are depths ranging from 100 to 146 fathoms, the latter being the deepest sounding between the British Islands. Off the Antrim coast in the neighbourhood of Rathlin Island are soundings in a very small area of 130 to 136 fathoms. Near the entrance of Loch Fyne is a very small pit with a depth of 104 fathoms. Further north, off the west coast of Ross-shire between Applecross and the Island of Raasay, there is a narrow trough in which there are depths of 130 to 136 fathoms. On the eastern side of our islands in the North Sea, there is only one spot where the sounding of 100 fathoms has been found, and this is at the outermost southern corner of the Moray Firth to the north of Kinnaird Head, and very near to the coast.

It is most remarkable that while our seas are thus shallow, there is a lake in Scotland in which the depth is greater. Sir John Murray, who has devoted so much time and money to his great survey of the lakes of Scotland, kindly informs me that Loch Morar in Inverness-shire is $169\frac{1}{2}$ fathoms (1,017 feet) deep, that Loch Ness has in one place a depth of $125\frac{2}{3}$ fathoms (754 feet), and Loch Lomond 104 fathoms (624 feet).

It soon indeed became evident that our views as to the depth by which our fauna was limited must be extended. In 1861–1868 a Committee was appointed by the British Association for carrying out extensive dredging around the Shetland Islands. Of this Committee, the late Dr. Gwyn Jeffreys was chairman,

and I was one of the members. We gradually extended our dredging into deeper water until in 1867 we worked in 170 fathoms, about 35 miles in the ocean north-north-west of Burra Firth Lighthouse, which is situated on the most northerly rock of the Shetland Islands. This dredging had, at that time, only been surpassed in European seas by Professor Michael Sars, who published an account in 1868 of animals found by him in from 200 to 450 fathoms, but this was in the sheltered fiords of the Norwegian coast.

The question that remains to be determined is: What are the natural boundaries of the marine fauna of our own or of any country? I answer that the boundary is the base-line of the country or continent as it rests upon the bed of the ocean. If we are to admit any deep-water marine fauna at all, no other limit would appear to be reasonable. In shallow water we have little difficulty in defining certain zones. Thus there are: (1) *The Littoral Zone*, i.e. the shore between high and low water-mark, characterized by a fauna which in large measure requires that a portion of its life should be spent under atmospheric influence. (2) *The Laminarian Zone*, the region of seaweeds, which afford nourishment for those animals which live on a vegetarian diet. This zone may be said to extend to 20 fathoms. (3) What Forbes denominated *The Coralline Zone*, so named from its richness in Hydrozoic and Polyzoic life, on the existence of which, again, a large number of animals depend for their food. But beyond this no distinct line of demarcation can be drawn, for although we may talk of the Abyssal or Abysmal Region, there is no marked difference, at any one depth, of the conditions of life, and hence there is a gradual, and only gradual, intermixture of species. Therefore, no one stated depth, such as that of 100 fathoms, can be taken as the limit of a fauna.

To return to my statement that the boundary of the marine fauna is the base-line of the country or continent as it rests upon the bed of the ocean. If a stone is placed in a basin, and water poured in until almost the whole of the stone is covered, that portion of it which is covered by the water right down to the base where it rests on the basin is as much a portion of the stone as the part uncovered. Just so with an island or continent. The first thing therefore we have to determine is at what depth the floor of the ocean is reached. Now if we examine a chart of the North Atlantic we shall scarcely find a place in which there is a depth of less than 1,500 fathoms

which is not connected by lesser depths with adjacent land. The chief apparent exceptions to this are three patches in a line directly north of the Azores where lesser depths are met with so that one sounding gives only 625 fathoms. But even here the soundings taken have not been sufficient to exclude the possibility of a continual line under 1,500 fathoms in connection with the Azores. The bed of the whole of the North Atlantic, with the exceptions which I have mentioned, is covered by water at a depth of from 1,500 to 3,000 fathoms, but there is only one sounding, and that on the western side of the Atlantic, which gives so great a depth as 3,000 fathoms. The general range is from 1,500 to 2,500 fathoms.

Tracing now this 1,500-fathom line along the coast of Europe, we find that an enormous tract of ocean-bottom within this depth exists south of Iceland and west of Scotland. On reaching Ireland the area covered is of very much less extent. Here the Continental Shelf extends westward of the Shannon, roughly speaking, about 300 miles, with a depth rarely exceeding 250 fathoms. Then westward again, in a few miles, the Continent is propped up by vast buttresses, 5,000 or 6,000 feet in height, which rise from the bed of the ocean. Such a precipice is at one spot on the North Atlantic Chart represented by two soundings of 650 and 1,570 fathoms, the figures of which almost touch each other on the chart. This Continental Shelf, which name has been given to the submerged portions of the Continent, when followed southwards becomes rapidly less extended, so that from the Bay of Biscay southwards, for fully 2,000 miles along European and African coasts (beyond which it is not necessary to go), the Continental Shelf down to 1,500 fathoms has an average distance from land of only 60 or 80 miles.

We argue, then, that the limit of the British fauna to the west of our islands should be the base of the Continent at 1,500 fathoms. To the east, the mid-line between Continental Europe and Great Britain must be taken as the boundary.*

Northward, however, we meet with some peculiar circumstances; here to the east are the Shetland Islands, while westward lie the Faroë Islands. Between these groups of islands there is a deep trough known as the Faroë Channel. This trough has a depth of 500 to 600 fathoms. Directly south of it the ocean-bed rises more than 200 fathoms nearer to the surface, and this elevation, which has been accurately surveyed by Sir Wyville

* For a more detailed account see A. M. Norman, "The 'British Area' in Marine Zoology," 'Ann. Mag. Nat. Hist.,' ser. 6, vol. v, 1890, p. 345.

Thomson and Sir John Murray, is known as the Wyville Thomson Ridge. This ridge is a most important factor in the distribution of life. Its biological influence is of necessity very great. The so-called Gulf Stream, flowing north with a depth of 500 to 700 fathoms, is interrupted in its progress. Meeting with this ridge it can only overflow it with a depth of 200 to 300 fathoms, and while it influences the whole of the ocean to the bottom south of the ridge, so that the bottom temperature here at 500 to 600 fathoms is 45° to 46° Fahr., north of the ridge it has no influence in the Faroë Channel below the depth which it has in passing over the ridge, and the bottom temperature falls to 29° or 31° Fahr. Thus geographically we here find the Atlantic Ocean with Atlantic temperature on the north bounded by the Wyville Thomson Ridge, while just north of this the Faroë Channel is found to be a southern tongue of the Arctic Ocean, with the temperature which belongs to that ocean. Such differences cannot but affect the conditions of life, and we find that many southern species reach the Wyville Thomson Ridge, but are absent in the Faroë Channel, while Arctic species are met with in the latter which are absent in the former. The Wyville Thomson Ridge, therefore, must be taken to be the limit both of the Atlantic Ocean and of the British fauna; while the Faroë Channel, both geographically and zoologically, must be assigned to the Faroë Islands.

Professor Edward Forbes divided the European marine fauna into Provinces. Of these Provinces we are concerned with that which he named the Celtic. This, as defined by him, extended from Cape Finisterre in the south to Denmark in the north, and included the Baltic, except its northern shores. Thus it embraced our islands, except the Shetland Islands, which he transferred to the Boreal Province.

Our present knowledge of the fauna of the Bay of Biscay at one extremity, and of the Shetland Seas at the other, would make it seem desirable that Ushant, instead of Cape Finisterre, should be the southern boundary, while the seas of Shetland should be removed from the Boreal Province into the Celtic.

But just as the British Islands intervene between the north and south portions of the European Sea, so their fauna in the south partakes of characteristic animals which have their home in the Lusitanian and Mediterranean Seas, and in the north the fauna is intermingled with species of northern or Arctic origin.

I now pass to some peculiar conditions which affect those

animals which are denizens of the North Sea from the Straits of Dover to the North of Scotland. In a paper on the Shetland Fauna read before the British Association in 1868,* I wrote thus:—"The distribution of animal life around our coasts appears for the most part to have followed the direction south, west, north, east. It would seem that comparatively very few, if any, southern species have made their way north through the Straits of Dover, which may probably be accounted for by the fact that that channel has, geographically speaking, been only a short time open.† As a rule, southern species are to be seen at a higher latitude on the western than they are on the eastern coasts. There are, however, some apparent, but only apparent, exceptions. These consist of animals known on the north-east coast of Scotland, which we should not have expected to meet with there. On examining into the probable cause of their migration to this district, I am led to believe that they have made their way thither round the western and northern, and down the eastern coasts, to their present habitats, and not up the eastern coast as might at first have been supposed. For example, *Cerithium perversum*, *Phasianella pulla*, *Fissurella græca*, *Tellina balaustina*, *Callianassa subterranea*, *Palmipes placenta*, *Amphiura brachiata*, etc., have been found in the Moray Firth, but are wholly unknown on the eastern coast of England." During the forty years which have since passed other facts have come to light with respect to certain species and the apparent migrations down the east coast of Scotland and England of some oceanic forms, which greatly strengthened the zoological evidence.

First, the Arctic naked Pteropod, i.e. a mollusk which swims with a pair of wing-like organs, and which is so abundant in the Greenlandic Seas that it forms no inconsiderable part of the food of the Greenland whale, has occurred on several occasions off the east coast of Scotland. Next, there is a remarkable case of migration southwards of a littoral rock-loving limpet, *Acmæa testudinalis*. No part of the British coast had been more thoroughly explored than Northumberland. Yet in all their searches, neither Johnston nor Alder nor Hancock had ever seen this mollusk. But in 1856 and 1857 it was met with at the Farne Islands [Tate] and Whitburn [Abbes],

* "Shetland Final Dredging Report. Pt. II. On the Crustacea, Tunicata, Polyzoa, Echinodermata, Actinozoa, Hydrozoa, and Porifera," by the Rev. Alfred Merle Norman, M.A., 'British Assoc. Report for 1868.'

† From what follows the reason given here is perhaps questionable.

and in 1857 at Roker [A. Hancock].* Soon after this it was found to have made its way southwards to Hartlepool. Next it reached Scarborough and its neighbourhood, and for physical reasons which will presently be stated it may be supposed that this will prove to be about its southern limit. It is an interesting fact that the first person who found this limpet on the Northumberland coast was the famous Grace Darling. A miscellaneous, child-like collection of single valves and dead shells collected by her was some years ago brought to the Newcastle Museum. Among these shells was an example of *Acmæa testudinalis*.

Strong confirmatory evidence is to be found in what appears to be the southern migration down the east coasts of Scotland and England of vast shoals of oceanic Crustacea. In 1866 Thomas Edward published a paper entitled "On the Habits of the Hyperiadæ."† Having procured some common herring, immense shoals of which were then off the coast, but which he says only seldom occurred, he examined their stomachs and found them to be filled with a small Crustacean, *Euthemisto compressa*, of which he found 59 in one stomach, 47 in another, and 33 in a third, and all the others more or less crammed. He then proceeds—"Now if all the herrings composing these shoals had been as well supplied as those I dissected (and we cannot tell that they were not), how amazing must have been the number of the Crustacea. It is likewise worthy to remark that these herrings were taken at from 4 to 5 miles from land or perhaps more. Again, I have also seen them cast on the shore during gales from the north" (Banff lies on the south side of the Moray Firth) "in most enormous and incalculable numbers. On one occasion and for some distance our rock-pools were literally one living mass of them. But if I was astonished at this, what was my surprise on reaching the sands which run continuous to the rocks alluded to at beholding a ridge or wall of these animals extending more than 100 feet in length, and varying from one to two inches in height and breadth, which had been washed up from the sea! And instead of lessening, each succeeding wave only added thousands upon thousands to the general wreck." On another occasion a still larger portion of sand was strewed with these animals.

In 1868 Mr. George Sim, writing in May, told me that "certain Schizopod Crustacea had been cast on the beach in

* 'Trans. Tyneside Nat. Field Club,' vol. iv, p. 68, and vol. v, pp. 59 and 62.
† 'Proc. Linn. Soc.,' vol. ix, 1867, p. 166.

considerable numbers some time ago." Among these were *Rhoda Raschii*, M. Sars, *Thysanoessa neglecta*, Kröyer, *Nematoscelis borealis*, Norman, and *Nyctiphanes norvegica*, M. Sars. Professor M'Intosh observed on 22nd April, 1886, *Nyctiphanes norvegica* and *Thysanoessa longicaudata* to have been thrown up in enormous quantities in St. Andrew's Bay. So dense was their mass that he states: "the tidal wave was crowded with them, and miles of sand were strewed with their bodies, which the receding wavelets left in streaks and curves." * Of these two Crustacea, the *Thysanoessa* was an Arctic species not previously known in our fauna.

In 1892 Mr. Thomas H. Nelson, writing from Redcar, North Yorkshire, records another similar migration. He writes: † "February 10th, 11th, and 12th. Attracted by the number of kittiwakes (*Rissa tridactyla*) to be seen about a mile out to sea, I procured a boat and went off to ascertain the cause of this vast assemblage of gulls. Both east and west, as far as the eye could reach, their graceful white forms were visible, many busily engaged dipping into the water, and others flying overhead and then darting down to pick up some object from the surface. I shot two or three examples and found that their mouths were full of small crustaceans, with which the sea was literally alive; heaps of these were afterwards washed ashore by sea-winds, and afforded a feast for starlings and other frequenters of the tidal line." Mr. Nelson sent some of these to me for determination. There were two of the Schizopoda already mentioned, *Thysanoessa longicaudata*, Kröyer, and *Nematoscelis borealis*, Norman, but the mass consisted of *Euthemisto compressa*, Goës. ‡ Again, in 1894, Mr. Nelson wrote and sent examples of *Euthemisto compressa*, which in that year had been thrown up in vast quantities. While writing this paper I enquired of Mr. Nelson if he had observed any occurrence of the same kind since 1894. My letter reached him on April 10th, and curiously in reply he said that two days before large quantities of Crustacea had been found upon the beach. He adds, "before it was too dark to-night I went

* 'Ann. Mag. Nat. Hist.,' ser. 5, vol. xix, 1887, p. 140.

† 'The Naturalist,' May, 1892, pp. 144 and 175.

‡ The Amphipod referred to is named by Bate and Westwood in their work *Hyperia oblivia*, Kröyer, but in 1868 I pointed out that it was not Kröyer's species, and named it *Hyperia gracilipes*. That name has been accepted by carcinologists, but I am now of opinion that it is a small southern form of *Euthemisto compressa*, Goës, which is without the dorsal spination characteristic of Arctic examples. It might perhaps be most correctly named *Euthemisto compressa*, Goës, var. *gracilipes*, Norman.

down to the beach, and although what had been cast up two days previously had been apparently consumed by the birds, lower down the tide-marks I still found them lying." A small tin full of these mixed with sand he sent to me. It contained thousands of *Euthemisto compressa*. He also wrote, " at intervals perhaps of two or three seasons there have been large numbers of Crustaceans thrown up, as nearly as I can remember in 1898 and 1901, again I think about 1904 and 1906, 1907 and 1908. Each year they appeared in February or March and once in May, *always* with the wind at north or north-east, not necessarily in stormy weather, but perhaps with gentle breezes from the quarter mentioned."

Whence come these vast swarms of Crustacea? Are they bred in the North Sea between the continent of Europe and the British Islands or brought down by currents from farther north? Tow-netting in the former region has not given evidence, so far as I know, to lead to the first conclusion, while the intermixture of high Arctic Schizopoda with the Amphipoda I think clearly points to the second solution. I cannot but think that tow-netting with a view to discovering the origin of these swarms would lead to conclusive results as to the direction from which the inflowing waters of the North Sea in the winter months are derived. Given a knowledge of the rate of the inflowing stream, it would not be difficult to calculate from the North-Yorkshire coast the approximate place northwards where they might be expected to be found, while it is not unlikely also that flocks of gulls feeding upon them might give evidence of their presence.

On the 26th of July last year (1907) a very interesting addition to our Crustacean fauna was made in the North Sea. Mr. R. A. Todd, when trawling in the " Huxley," which is the British steamer engaged in the work of the International Commission, brought up from 57 fathoms on a muddy bottom E.N.E. of the Coquet Lighthouse on the Northumberland coast, about thirty specimens of *Pandalus borealis*, Kröyer. This large prawn attains a length of $5\frac{1}{2}$ inches, and is thus considerably larger than our finest English prawns. It is a truly Arctic species which is found all round the Pole. It occurs, moreover, in places down the Norwegian coast, and reaches the Christiania Fiord. But in that fiord until recently this prawn had only been found in one place. Now it has been proved to be living throughout the fiord in depths of about 60 fathoms on a muddy bottom, and in one comparatively small but deep bay

it was found in such great abundance that in the course of half a day several bushels could be brought up by the aid of a trawl.* The chief point of interest in connection with these examples from off the Northumberland coast lies in the answer to the question, how came these prawns in the place where they were trawled? Were they living in the North Sea as their home? If that were the case, it seems scarcely probable that they could have been so long overlooked. Had they then been brought down by the current flowing southwards along the Northumberland coast? Perhaps so, and in either case their future history must be regarded with interest, for should they hereafter prove to have multiplied in our waters, they may become of some commercial value, since Professor Sars tells us that they have "a very delicate flavour, and have always been very much esteemed." †

That such a current exists has during the last few years been clearly shown by the observations of hydrographic investigators of the North Sea Fisheries Investigation Committee and of the *Conseil Permanent International pour l'exploration de la Mer*. The conclusions of these bodies have been based upon data grounded on the greater or less extent of the salinity of the waters and of the microscopic organisms (Diatomaceæ, etc.) which they contain. The investigations have not yet reached that point where conclusions can be absolutely stated, but certain points seem clearly established.

First, that there is a current passing down the western side of the North Sea to about as far as Flamborough Head, then bending eastwards, parallel with the waters coming up through the Straits of Dover, together they pass northward along the eastern side, leaving comparatively unaffected the centre of the area. But whence comes the current which flows down the British coast? It seems proved that during the summer months it is supplied by water of the highest salinity, which passes up from the Atlantic and is, in fact, a portion of the Gulf Stream, intermixed with water of less salinity which it has associated with itself in passing through the Irish Sea or round the western coast of Ireland. But in the winter season the so-called Gulf Stream, which has been flowing northward at the rate of

* G. O. Sars, "Account of the Postembryonal Development of *Pandalus borealis*, Kröyer." 'Report Norwegian Fishery and Marine Investigation,' vol. i, 1900, No. 3. It is now frequently sent from Norway to our markets.

† Many other Arctic Crustacea have been observed in the more southern portion of the North Sea. Off the coast of Scotland Dr. Thomas Scott has obtained *Euthemisto bispinosa*, Boeck, *Tryphœna Malmi*, Boeck, *Byblis Gaimardi*, Kröyer, *Anonyx nugax*, Phipps, and off the Northumberland coast I have taken *Protomedeia fasciata*, Kröyer, *Unciola planipes*, Norman, etc.

about 15 miles in 24 hours, becomes lessened in volume and rapidity. At this season the Swedish observers Pettersson and Ekman are of opinion that a current runs southward from the north-east coast of Iceland to the North Sea. This hypothesis is mainly based on the biological conditions, since the plankton within the entrance to the Baltic contains numerous Norwegian forms. "It has been shown by Ryder that a large portion of the East Greenland Polar current turns eastward running past the east coast of Iceland." They find support for their theory in the drift of a bottle which was sent afloat by Ryder off the south coast of Iceland, and after the lapse of a year was picked up off Heligoland.*

Mr. A. J. Robertson states:† "The greater part of the north-western area of the North Sea was in February, 1904, flooded by cold salt Atlantic water which was then streaming through the Channels south of the Shetlands." "The temperatures and salinities of the various stations" (where observations were taken) "were then quite uniform from surface to bottom, the salinities being somewhat higher and the temperature slightly lower than at the more westerly line of stations. The higher salinity evidently indicated that the saltest water was then entering the North Sea partly round the North of Shetland; the lowering of the temperature was due to the cooling already effected on the warm Atlantic water since passing the channels south of Shetland." Helland Hansen‡ believes it is shown that "the salt water at the surface of the northern part of the North Sea in December had two sources; the chief source was an increased influx of water from the Atlantic stream in the Norwegian Sea, and the other source was a transference of salt water from the bottom by vertical currents." Professor D'Arcy Thompson gives as a summary:§ "We have confirmation of the view that the Atlantic current bending round our northern coasts into the North Sea is marked by an annual pulse, intensified in the earlier and shrinking in the later months of the year."

Thus more recent zoological and physical observations tend to prove that my statement in 1868 that "the distribution of animal life around our coasts appears for the most part to have followed the direction from south to west, then north,

* Hjort and Gran, 'Currents and Pelagic Life of the Northern Ocean,' p. 5.

† A. J. Robertson, 'North Sea Fisheries Investigation Committee,' "Second Report (Northern Area), for 1904–5," 1907, p. 12.

‡ *Ibid.*

§ 'North Sea Investigation Committee' (as already referred to).

thence east" was well founded. The second part of my statement was: "It would seem that comparatively very few, if any, southern species have made their way far north through the Straits of Dover." Recent investigations have confirmed and at the same time accounted for this statement.

With a view of tracing the direction of the flow of the waters from the south which enter the Straits of Dover, Mr. George P. Bidder made use of a large quantity of submerged bottles. These bottles were so weighted that a wire suspended from them was just dragging along the bottom. Thus wind-action had no influence on the course they took. Within each bottle was a paper requesting the trawler or other finder to return it to the experimenter with an exact account of where the bottle had been met with. East of the Wash and Lowestoft 390 bottles were sent forth on their mission at a distance from each other of a quarter of a mile, and of these 221 were recovered in the first year. A second series of 270 were sent forth, and of these 158 were recovered in one year. Other similar experiments followed. From the direction taken by these bottles it was proved that a coastal current runs the first half of the year from west and south to east and north along the shores of Vlieland, Friesland, Holstein, and Denmark, with a velocity of from a mile to two miles a day. This current certainly goes up to Amrom and the Sylt, and probably to the Cattegat. It would seem likely that it is essentially a winter and spring current. Mr. Bidder's general conclusion is that "the course of the drifters is by no means rectilinear and is presumably cycloidal; the motion being resultant from steady drift and far more rapid tides."

The following results appear to come out. First, that the waters entering through the Straits of Dover take a northerly direction to about as far north as Lowestoft; that they then sweep across to the eastern portion of the North Sea. On the other hand, the currents coming from the north-west along the Scottish and English coasts are thrown back by the southern streams from the south of Dover, and consequently are swept round and passed northwards on the outer eastern portion of the sea. Thus there would be comparatively little current motion in the centre of the North Sea.

The North Sea has long been famous for certain fine and rare Mollusca which are found in its deepest parts, and for very many years this was the only locality known for them, and they were sold for very large sums. At the present time many of them have a range extending northwards to Vardo in East Finmark, while

to the south some of them are dredged off the west coast of Ireland and even off the coast of Brittany, but it is only in the North Sea that they occur in such shallow water as 50 to 60 fathoms. It is from this so-called "Dogger-Bank" source that conchologists still for the most part obtain their specimens of these Mollusca. The species are *Modiolaria nigra*, Gray, *Panopea norvegica*, Spengler, *Calliostoma occidentale*, Mighels, *Liomesus Dalei*, J. Sowerby, *Volutopsis norvegicus*, Chemnitz, *Beringius Turtoni*, Bean, *Buccinofusus berniciensis*, King, *Lunatia pallida*, Brod. and Sow., and *Amauropsis islandicus*, Gmelin. Other shells of considerable interest which accompany these are *Scalaria Trevelyana*, Leach, a large form of *Tritonofusus gracilis*, Costa, named by Jordan var. *Belliana*, and a giant form of *Modiola modiolus*, Linn., reaching 7 inches in greatest diameter.

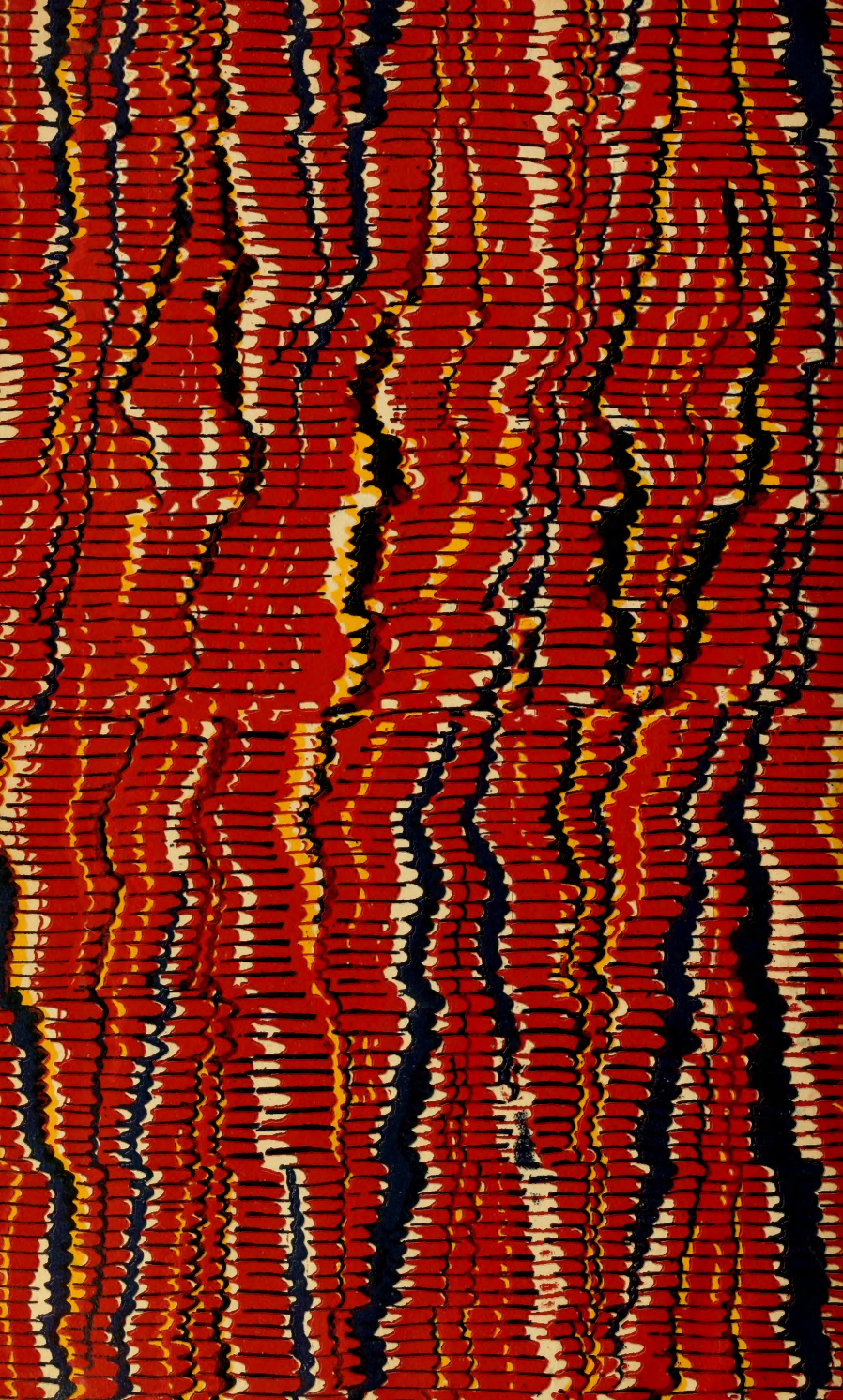
There is an interesting case of one species of the Polyzoa which appears to have migrated in a particular form from the southern coasts of France to the coast of Norway, but is unknown in the British Islands. The species is *Electra pilosa*, Linn., which is found on every part of the British coast, but always in an incrusting form, and no single example has ever been met with assuming a state independent of the seaweed, shell, or stone to which it adheres. In the extreme south of France, however, for example at Biarritz, a very beautiful form, *Electra verticellata*, Lamouroux, is found, which may or may not be a very extreme variation of *E. pilosa*, but, at any rate, in the Bay of Biscay the true *E. pilosa* occurs, growing erect as a little shrub. I have specimens, again, of this erect form from the Belgian coast, where it is extraordinarily abundant, and Pallas, writing one hundred and twenty-seven years ago, stated that it was thrown up there on the shore in cart-loads. Northwards I have dredged this free form on the Norwegian coast, in the Bergen Fiord, and even so far north as Florö. In this latter locality it takes upon itself a marvellous variety in cell-building, and assumes very varied forms of free growth.* The absence of the free-living forms on the British coast is very remarkable, and it would appear as though the larval state of this variety had never been able to migrate across the Channel. There are other species on the Belgian coast which are unknown in our seas.

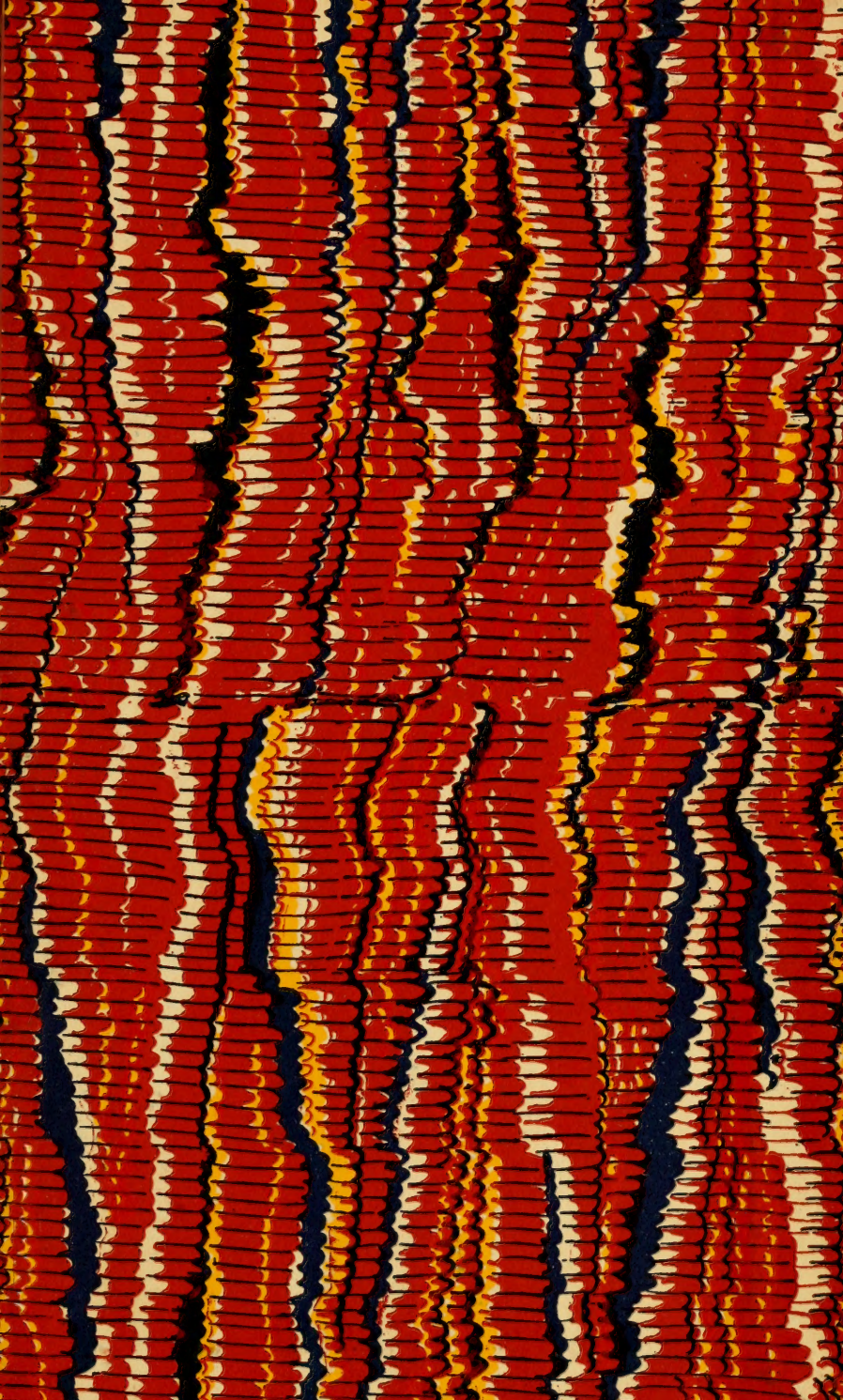
Much interest attaches to the investigation of the fauna of the Continental Shelf of the west of Ireland, now being carried out by the Commission of the Sea and Inland Fisheries of

* A. M. Norman, "A Month in the Trondhjem Fiord," 'Ann. Mag. Nat. Hist.,' ser. 6, vol. xiii, 1894, p. 113.

Ireland. The shallower waters of the west of Ireland have long been known to be extremely rich with respect to their Invertebrate fauna. But now Mr. E. W. L. Holt and his able coadjutors have carried investigations down to 500 and even 1,000 fathoms, and have brought to light a fauna of extraordinary richness. The material has as yet only been partially worked out, but the results in many classes are truly astonishing, including species previously only known in distant localities north and south, together with a large proportion of new forms.

N.J.R. DEC 16 1909





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